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SHORT COMMUNICATION

Notes on *Lagothrix flavicauda* (Primates: Atelidae): oldest known specimen and the importance of the revisions of museum specimens

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ABSTRACT. The yellow-tailed woolly monkey, *Lagothrix flavicauda* (Humboldt, 1812), is a large atelid endemic to the cloud forests of Peru. The identity of this species was uncertain for at least 150 years, since its original description in 1812 without a voucher specimen. Additionally, the absence of expeditions to the remote Peruvian cloud forests made it impossible to collect material that would help to confirm the true identity of *L. flavicauda* during the 19th and first half of the 20th century. Until now, the specimens of *L. flavicauda* collected by H. Watkins, in 1925, in La Lejía (Amazonas, Peru) were thought to be the oldest ones deposited in any scientific collection. Nevertheless, after reviewing the databases of the several international museums and literature, we found one specimen of *L. flavicauda* deposited at the Muséum National d'histoire Naturelle (Paris, France) collected in 1900 by G.A. Baër, in the most eastern part of San Martín (Peru), where the presence of this species was not confirmed until 2011. Thus, Baër's specimen represents the oldest known specimen of the yellow-tailed woolly monkey and the only one coming from the eastern part of the species' distribution. Finally, we highlight the importance of online scientific databases for easily diagnosable species. However, caution needs to be taken when using them. We also discuss the value of scientific collections as sources of new discoveries.

KEY WORDS. Distribution, history, taxonomy, yellow-tailed woolly monkey.

Brief taxonomic history of *Lagothrix flavicauda*

The yellow-tailed woolly monkey, *Lagothrix flavicauda* (Humboldt, 1812), endemic to the Peruvian cloud forest in the Departments of Amazonas, San Martín, Loreto, and Huánuco (Leo Luna 1989, Shanee 2011), is one of the rarest and most threatened primates in the Neotropics. The yellow-tailed woolly monkey is also poorly-represented in scientific collections. For more than 150 years after the original description of the species, nothing was known beyond what was written in specimen's labels and naturalists' field notes.

The taxonomic history of *L. flavicauda* began with Humboldt (1812) who reported "Le choro de la province de Jaen" during his travel with Aimé Bonpland through South America (1799–1803). Humboldt (1812) described this species as a brownish-black monkey, with arms and thighs a tone more obscure than the back, a yellowish-brown face, a prehensile tail shorter than the body, of an olive black and laterally adorned with two yellow stripes. However, no specimen was collected on that expedition. Humboldt (1812) originally considered *L. flavicauda* as an unknown species of howler monkey (genus *Alouatta*), naming it as *Simia flavicauda*. This author also reported that this species was traded in the region of Jaén and Maynas in the Departments of Cajamarca and Loreto (both in Peru), respectively. Although not supported by any voucher specimen, Humboldt's (1812) description leaves no doubt about the uniqueness of *L. flavicauda* but, based solely on this description, several authors reproduced the erroneous idea that *L. flavicauda* would represent a howler monkey species. Thus, *L. flavicauda* was listed as a member of *Mycetes* (Kuhl 1820, Wagner 1840, Lesson 1840, von Tschudi 1844, I. Geoffroy Saint-Hilaire 1851, Schlegel 1876), *Stentor* (É. Geoffroy Saint-Hilaire 1812, Cuvier 1837), and *Alouatta* (Forbes 1896, Elliot 1913, Tate 1939), being the two former genera junior synonyms of the latter.

The misunderstanding about the real identity of Humboldt's *Simia flavicauda* increased with the description of *Lagothrix* (*Oreonax*) *hendeii* (Thomas 1927a). This same author

claimed that the morphological differences of the monotypic subgenus *Oreonax* deserved a generic distinction from *Lagothrix*, containing *O. hendeii* (Thomas 1927b,c). Thomas (1927a,b,c) based his description on material collected by R.W. Hendee in Puca Tambo (San Martín, Peru) in January 1926. In Thomas' vision, his *Oreonax hendeii* clearly represented a different species of Humboldt's *Simia flavicauda*. Thomas (1927b) concluded that Humboldt's *S. flavicauda* was probably nothing more than "a local *Lagothrix*, perhaps *L. lagothricha*". This taxonomic confusion led Tate (1939: 214, 217) to consider Humboldt's *Simia flavicauda* a composite taxon containing two different species, [*Lagothrix*] *hendeii* and [*Alouatta*] *flavicauda*. On the other hand, Cabrera (1958: 153, 183) stated that Humboldt's *Simia flavicauda* could be a valid but undeterminable species of *Alouatta* and recognized Thomas' *Lagothrix hendeii* as a valid species. Hill (1962: 250) also considered *L. hendeii* as a valid species making no mention to Humboldt's *Simia flavicauda*. Nevertheless, these two latter authors considered that the characters presented by Thomas (1927b,c) to sustain *Oreonax* as full genus had no more than specific value and retained *hendeii* within *Lagothrix*. Fooden (1963) performed the first comprehensive taxonomic revision of the genus *Lagothrix*, finally resolving the identity of Humboldt's *Simia flavicauda*. After reviewing the available literature and comparing museum specimens, Fooden (1963) found that Humboldt's *Simia flavicauda* and Thomas' *Oreonax hendeii* represented the same species of woolly monkey.

Fooden's (1963) taxonomic arrangement was largely accepted (Napier 1976, Eisenberg and Redford 1999, Nowak 1999), until Groves (2001) tested the phylogeny of the atelids. This latter author, based on a 50% majority rule consensus tree estimated via a parsimony analysis of only 20 cranial characters and an undetermined number of species, found out that *Lagothrix flavicauda* was more closely related to species of *Ateles* than to *L. lagothricha*. These low-supported results (bootstrap support <70%) led Groves to resurrect Thomas' *Oreonax* for *flavicauda*. Groves' (2001) proposal was rapidly accepted (Groves 2005, DeLuycker and Heymann 2007, Rylands and Mittermeier 2009); nevertheless, the use of *Oreonax* as a formal genus for *flavicauda* was also criticized. Matthews and Rosenberger (2008) and Rosenberger and Matthews (2008) replicated and extended Groves' (2001) study and showed that his results were probably a sampling artifact, which undermined the logic of reviving *Oreonax* as a formal genus for *flavicauda*. However, as noted by Pacheco et al. (2009), these authors did not provide a phylogeny that placed *flavicauda* within *Lagothrix*. More recently, molecular evidence has also refuted Groves' (2001) results. Ruiz-Garcia et

Figures 1–4. *Lagothrix flavicauda* (MNHN-ZM-MO-1901-1602) collected by G.A. Baër in September 1900 in the Hacienda Nuevo Loreto (San Martín – Peru): (1) complete skin; (2) close-up of the tail showing the diagnostic yellow-golden hairs surrounding the tail's digital patch; (3) close-up of the face showing the white circumbuccal patch; (4) original Baër's label of the specimen. Photographs provided by Jacques Cuisin (MNHN).

al. (2014) and Di Fiore et al. (2015) presented the first molecular phylogenetic analyses of *Lagothrix flavicauda*. The results of both studies were similar, supporting a monophyletic *Lagothrix* that included *flavicauda* and the other woolly monkey species, agreeing with Fooden's (1963) taxonomic arrangement.

The oldest known specimen of *Lagothrix flavicauda*

As a part of an ongoing study, we were looking for specimens of *Lagothrix flavicauda* deposited in scientific collections or cited in the literature. We found 17 skins and 8 skulls deposited in the following collections: Museo de Historia Natural, Lima, Peru (11 skins, 3 skulls); American Museum of Natural History, New York, USA (AMNH; 2 skins, 2 skulls); Natural History Museum, London, UK (NHM; 3 skins, 3 skulls); and The Museum of Vertebrate Zoology, Berkeley, USA (MVZ; 1 skin). All these specimens have been referenced in the literature somehow. Additionally, Kuhl (1820: 30) stated that one specimen of *Mycetes flavicaudatus* (a synonym of *Lagothrix flavicauda*) was held at the Muséum National d'histoire Naturelle (MNHN, Paris – France). Nonetheless, Elliot (1913: 277) said that this must have been a mistake since he could not find that specimen in the collection and É. Geoffroy Saint-Hilaire (1812) never mentioned it either. Nevertheless, we found one skin at the MNHN, collected in 1900 by G.A. Baër, which until now had not been mentioned in the literature.

Between 1900 and 1901, G.A. Baër traveled throughout South America collecting several animals, most of which were birds. He also collected a considerable number of mammals, including rodents, marsupials, and primates. While in Peru, he traveled to some inhospitable areas between June and December of 1900. One of the specimens collected by Baër was an adult individual of *Lagothrix flavicauda* (Figs 1–4). This specimen was collected at the Hacienda Nuevo Loreto in the Department of San Martín in September 1900 (Simon 1902, Stephens and Traylor Jr 1983). Simon (1902) described this locality as a warm forest region of the Río Mixiollo (= Río Mishollo) valley, three days East of Tayabamba, and at an altitude of 1200 m.a.s.l. (Fig. 5). All of Baër's material was shipped to Paris and housed in the collection of the MNHN. At the MNHN, this specimen was identified as a *Cebus* sp. under the catalog number MNHN-ZM-MO-1901-1602. The skin deposited at this museum represents, chronologically, the oldest known specimen of *L. flavicauda* deposited in a scientific institution.

After 50 years without any records, Mittermeier et al. (1977) registered *L. flavicauda* in Pedro Ruiz Gallo (Amazonas, Peru) and, without knowing Baër's record, they stated that the first specimens collected of *L. flavicauda* were those held at the AMNH. These two specimens were provided by H. Watkins, who collected them at La Lejía (Amazonas, Peru) in April 1925. In 1926, R.W. Hendee, a collector for the Godman-Thomas Expedition to Peru, collected three more specimens, those used by Thomas (1927a, b, c). Based on the available data at that time, Mittermeier et al. (1977) proposed that the distribution range of *L. flavicauda* would encompass the southern part of Amazonas and the mountainous western part of San Martin.

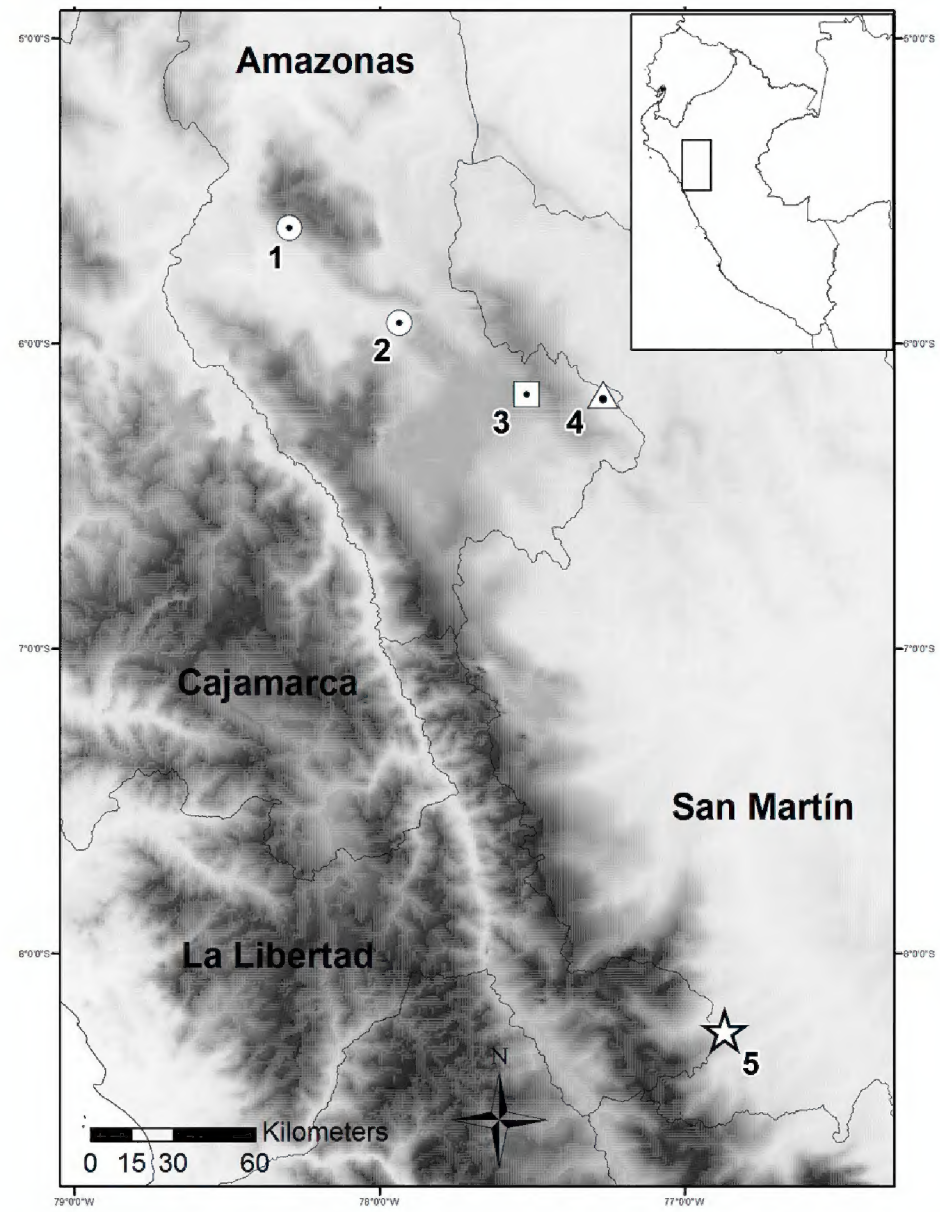

Figure 5. Map showing the historical confirmed records of the *Lagothrix flavicauda* specimens deposited in scientific collections. MUSM (circle). AMNH (square), NHM (triangle), and MNHN (star). For locality data, see Table 1.

The northern limit of the distribution of *L. flavicauda* was confirmed in several studies after its Mittermeier et al.'s (1977) record (Leo Luna 1980, Butchart et al. 1995). Nonetheless, its Southern limit remained uncertain for several decades. N. Shanee et al. (2007), based on information given by local guides, informed that this species inhabits the eastern portion of San Martín (40 km west of Tocache, approximately). A few years later, S. Shanee (2011) confirmed the presence of *L. flavicauda* in eastern San Martín. Recently, Aquino et al. (2016) recorded five groups of *L. flavicauda* on the eastern side of the Huallaga River, between Oso Mayo and Palizada (Huánuco, Peru) expanding its southern limits. Although Baër's specimen remained unnoticed, its importance is remarkable. It is not only the first record of *Lagothrix flavicauda* in eastern San Martín, more than 100 years before S. Shanee's (2011) survey, but also, as far as we know, it is the only specimen coming from that region in any scientific collection. Furthermore, if this specimen had been discovered before, the area where it was collected could have been taken into account in the early conservation programs developed for *L. flavicauda*. For example, this area could have been considered to be protected in the buffer zone of the Río Abiseo National Park created in 1990.

Table 1. Summary of the historical records of *Lagothrix flavicauda*, arranged in latitudinal order.

Locality #	Locality	Coordinates	Source
1	Alva (between Chachapoyas and Bagua Grande), Amazonas	5°56'S 77°56'W	MUSM 41, 42, 43, 44, 45
2	Comunidad Las Higueras, Campamento El Triunfo, Amazonas	5°37'S 72°17'W	MUSM 23155
3	La Lejía, Amazonas	6°10'S 77°31'W	AMNH 73222, 73223
4	Puca Tambo, Amazonas	6°10'S 77°16'W	BMNH 27.1.1.1, 27.1.1.2
5	Hacienda Nuevo Loreto, San Martín	8°15'S 76°52'W	MNHN-ZM-MO-1901-1602

The importance of reviewing museum specimens

The specimen of *Lagothrix flavicauda* collected by Baër represents a good example of the importance of thoroughly revising specimens in scientific collections. There are notable examples of new species that were described based on museum material long after the type specimens were collected: *Pithecia vanzolinii* Hershkovitz, 1987, *Callicebus vieirai* Gualda-Barros, Nascimento & Amaral, 2012 and *Mico marcai* (Alperin, 1993).

Vanzolini's bald-faced saki, *P. vanzolinii*, was described based on a large set of samples that remained unnoticed in at least three different Brazilian collections: the Museu de Zoologia da Universidade de São Paulo, São Paulo (MZUSP); the Museu Nacional Universidade Federal do Rio de Janeiro, Rio de Janeiro (MNRJ); and the Museu Paraense Emílio Goeldi, Belém (MPEG). The majority of samples of *P. vanzolinii* were collected in 1936 by A.M. Olalla and other two samples were collected in 1956 by F. Novaes and M.M. Moreira, held at the MPEG (Nunes and Serrano-Villavicencio, 2017). De Vivo (1985) was the first to notice that the material of *Pithecia* collected by Olalla and held at the MZUSP possessed a particular phenotype; nevertheless, he did not recognize this material as a different taxon. It was not until Hershkovitz (1987) that this species was formally described, originally as a subspecies of *P. irrorata*.

Another example is Gualda-Barros et al.'s (2012) *C. vieirai*. The holotype and the paratypes of Vieira's titi were collected in 1997 by Marília Kerr and in 1988 by J.L. Silva-Filho, respectively. All these specimens were kept in the collection of the MZUSP. Gualda-Barros et al. (2012), after revising the collection of *Callicebus* of the MZUSP, noticed that the phenotype of those specimens, deposited there for at least 15 years, was different, and described it as a new species.

As a final example, Marca's Marmoset, *M. marcai*, was described using material collected by the Comissão Rondon in 1914 and held at the MNRJ. This material remained unnoticed in various revisions of callithricids (Hershkovitz 1975, 1977, Ávila-Pires 1969, de Vivo 1991); Alperin (1993) noticed that these specimens represented a different taxon describing it as *Callithrix argentata marcai*. Van Roosmalen et al. (2000) described the marmoset *Mico manicorensis* (Roosmalen, Roosmalen, Mittermeier & Rylands, 2000); nevertheless, the authors did not analyze the type material of *M. marcai* and this later species was found to be a synonym of the former (Garbino 2014).

This kind of 'museum discovery' it is not unusual, but the lack of thorough reviews of scientific collections, especially the old ones, is alarming and may also have important consequences for conservation, as in the case of critically endangered species. The revision of scientific material brings not only new data and even new species in the middle of the present biodiversity crisis, but also has a tremendous potential to discover new or historical localities which must be viewed as opportunities to evaluate the real conservation status of a species over time (Graham et al. 2004). These historical distributional records provide unique opportunities to trace distributional changes in relation to threatening processes and thereby anticipate future impacts (Drost and Fellers 1996, Shaffer et al. 1998, Ponder et al. 2001, Graham et al. 2004).

Scientific collections have proved to be a source of new discoveries (Funk 2018); in this context, the efforts of all the museums worldwide to make their collections available in digital media should be highlighted and celebrated. However, we recommend that specialists, whenever possible, review these collections carefully to avoid identification mistakes and the posterior uncontrolled misuse of the museum's data. Finally, a proper maintenance of these collections must be guaranteed for future generations of scientists to have access to the valuable material and unfinished source of information that is deposited in them.

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